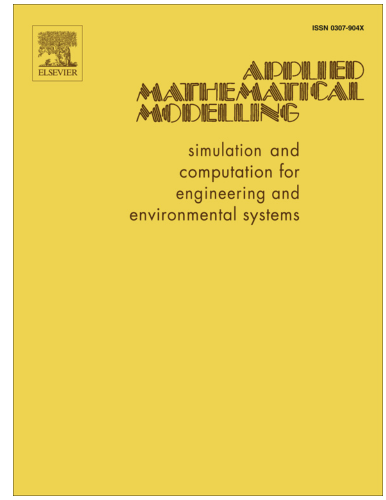
Accepted Manuscript



High-order tetrahedral finite elements applied to large deformation analysis of functionally graded rubber-like materials

J.P. Pascon, H.B. Coda

PII: S0307-904X(13)00236-9
DOI: http://dx.doi.org/10.1016/j.apm.2013.03.062
Reference: APM 9425

To appear in: *Appl. Math. Modelling*

Received Date: 8 September 2011
Revised Date: 28 January 2013
Accepted Date: 24 March 2013

High-order tetrahedral finite elements applied to large deformation analysis of functionally graded rubber-like materials

J.P. Pascon[a,*], H.B. Coda[a]

[a] *Department of Structural Engineering, São Carlos School of Engineering, University of São Paulo, Zip Code 13566-590, São Carlos, SP, Brazil*

Abstract

In this paper, high-order tetrahedral finite elements are employed to analyze structures and solids composed of functionally graded rubber-like materials under finite displacements, finite strains, statically applied forces and isothermal conditions. In order to do so, the following concepts are used: geometrically nonlinear analysis, Green-Lagrange strain tensor, second Piola-Kirchhoff stress tensor, hyperelastic constitutive relations, isoparametric solid tetrahedral finite elements of any order of approximation, and functionally graded materials. The equilibrium of the body is achieved via the Principle of the Stationary Total Potential Energy. The elements are fully integrated via Gaussian quadratures, and the resultant processing time is reduced by means of parallel techniques. To solve the nonlinear system of equations, the Newton-Raphson iterative procedure is employed.

The proposed formulation is validated by benchmark problems such as: the Cook's membrane and the thick cylinder. Other interesting simulation, the Cook´s block is proposed in order to evaluate high strain gradient situations. The results show that, in the context of the present study, locking-free behavior is obtained with simple mesh refinement.

Keywords: High-order tetrahedral finite elements; rubber-like materials; functionally graded materials; finite displacements and finite strains; static and isothermal analysis.

---

* Corresponding author. Tel.: +55 14 97868772, e-mail address: jppascon@gmail.com (J.P. Pascon)